INTERSPECIFIC VARIATIONS OF BARK´S WATER STORAGE CAPACITY OF CHOSEN TYPES OF TREES AND THE DEPENDANCE ON OCCURANCE OF EPIPHYTIC MOSSES

MEZIDRUHOVÉ ROZDÍLY VODNÍ KAPACITY KŮRY PRO VYBRANÉ DRUHY STROMŮ A ZÁVISLOST NA VÝSKYTU EPIFYTICKÝCH MECHOROSTŮ

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Abstract

Many studies show that the rates of water storage capacity can differ between different types of trees. The main purpose of this study was to compare specific water capacity of chosen types of woody species (*Acer pseudoplatanus, Betula pendula, Carpinus betulus, Malus sp*. as the representatives of broadleaved trees and as the representatives of coniferous were chosen species *Larix decidua, Picea abies, Pinus sylvestris*). In some cases the rates of water retention capacity between the chosen trees were considerable, e.g. the water retention capacity of *Malus sp* with the tree trunk perimeter of 100 cm was 0,886 g/cm^3 and water storage capacity of *pendula* with a tree trunk perimeter of 100 cm was 0,342 g/cm^3. There were big differences between the losses of moisture during a 24-hour period. The understanding of differences in interspecific variation of water retention capacity can help us to gain a better insight into occurrence of some organisms living on tree trunks and their dependence.

Abstrakt

Řada studií ukazuje, že hodnoty vodní kapacity se mohou u jednotlivých druhů stromu značně lišit. Účelem této studie bylo porovnat specifickou vodní kapacitu u sedmi vybraných druhů dřevin. Z listnatých dřevin byli vybrány tyto druhy *Acer pseudoplatanus, Betula pendula,Carpinus betulus, Malus sp*., Z jehličnanů byly vybrány druhy *Larix decidua, Picea abies, Pinus sylvestris*). V některých případech byly hodnoty vodní kapacity mezi jednotlivými druhy značné např. vodní kapacita stromu *Malus sp* s obvodem kmene 100 cm byla 0,886 g/cm^3 a vodní kapacita stromu *Betula pendula* s obvodem kmene 100 cm byla 0,342 g/cm^3. Velké rozdíly byly také ve ztrátě vlhkosti v průběhu 24 hodin. Poznání rozdílu mezidruhové vodní kapacity nám může pomoci v lepším pochopení závislosti výskytu některých organismů žijících na kmeni stromu.

Key words: bark water retention capacity, epiphyt moss, interspecific variation

1 INTRODUCTION

Specific bark water retention capacities (BWRC) differed significantly among co-occurring tree species. Bark water retention capacity is linked with the geoecology of temperate deciduous forests because stemflow volume and solute inputs are partly determined by bark water retention capacity (Levia and Herwitz, 2005). The volume of stemflow generated by canopy trees has been examined as a function of branch inclination angle, meteorological conditions and seasonality (Herwitz, 1987; Levia, 2004; Sood et al., 1993 in Levia and Herwitz, 2005).

Bark surface area, bark thickness, canopy architecture, and tree size and age have also been documented to affect stemflow yield (Helvey, 1967; Levia and Frost 2003 in Levia and Herwitz, 2005). The bark surface is texturally distinct in each vertical level. On the basis of field observations, the bottom bark was very rough with numerous fissures, whereas the top bark was smooth and unfissured. The bark of the mid section has an intermediate texture (http://findarticles.com/p/articles/mi_qa3845/is_200601/ai_n17183717/pg_2?tag=artBody;col1). We ascertained that bark surfaces generally stored larger quantities of water than foliar surfaces. On a per-unit-area basis, bark surfaces have larger water-holding capacities than foliar surfaces. For example, the specific water retention capacities of *Pinus sylvestris* pine needles ranged between 0,104 and 0,043 mm, depending on simulations of still air or windy conditions. These values are low when compared with the specific water retention capacity of branches and trunk, 0,62 mm. The water retained in branches and trunk therefore plays a key role in rainfall interception (Llorens and Gallart 2000). Adhesion between water molecules and bark within and between furrowed surfaces and capillary action within bark fissures. Water may also fill the pore space within bark. Water occupying pore space within bark and bark fissures are probable reasons for high water retention values per unit volume (http://findarticles.com/p/articles/mi_qa3845/is_200601/ai_n17183717/pg_2?tag=artBody;col1). Bark water retention capacity and moisture availability may have important implications for the distribution and diversity of epiphytic lichens and bryophytes. The composition and structure of corticolous bryophyte communities has been found to vary as a function of height above ground level and attributed to moisture availability on the trunk (Franks and Bergstrom 2000 in http://findarticles.com/p/articles/mi_qa3845/is_200601/ai_n17183717/pg_2?tag=artBody;col1). The purpose of this study is to test whether the specific bark water retention capacities differed significantly among seven chosen tree species. The chosen tree species are *Acer pseudoplatanus, Betula pendula,Carpinus betulus, Malus sp*. as the representatives of broadleaved trees and as the representatives of coniferous were chosen *Larix decidua, Picea abies, Pinus sylvestris.*

2 MATERIALS AND METHODS

The bark samples were collected from the chosen tree species, located west and south-west of the Ostrava region. The sample sites were the Osoblaha region, Odry region, Vsetín region. There were always 4 samples of bark taken from the tree trunk in each location. There were 84 samples of bark taken from all three localities.

The bark samples were collected from four trees of each chosen tree species on each sample site. The tree species were of different age. The bark samples were taken at a height of 1-2 m, approximately at breast height from all four cardinal directions. The samples were taken using a sharp knife. The ends of cut bark samples were sealed in the field using melted paraffin. The bark experiment employed methods as described by Levia and Herwitz (2005). All bark samples were air dried in the laboratory for one month prior to the bark water storage experiment to determine specific bark water storage capacities. Instantaneous water displacement of each bark sample in graduated cylinder provided a measure of bark volume. To determine bark water holding capacity, each bark sample was completely submerged in water-filled laboratory-based cylinders for >72 hours. Weighing the bark samples before and after submergence provided measurements of water volumes absorbed into the bark tissue. Bark samples were also dried for 60 minutes to document the length of time necessary for the bark samples to attain their original dry weighs.

Trunk surface area (cm^2) was calculated as

$$\log_{10}y = 2.6716 + 1.5881 \log_{10}x \quad (r = 0.989)$$

where y is stem bark surface area and x is tree diameter at breast height (dbh) (Whittaker and Woodwell, 1967 in Levia and Herwitz, 2005).

After the specific bark water retention capacity was determined, the percentage looses of water was determined in the laboratory after 1, 2, 3 and 24 hours. The determination of water loss was realized by comparing the weight of the wetted sample and the sample after 1, 2, 3 and 24 hours.

3 RESULTS

The laboratory measurements showed that out of the named trees species as *Picea abies* and *Malus sp had* the highest normative water storage capacity. The average means of specific bark water storage capacities for all samples (12 samples of bark out of one species) of *Picea abies* were 0,934 g/cm^3 and 0,914 g/cm^3 for *Malus sp*. (Fig.1.) Respectively *Picea abies* with a tree trunk perimeter of 0,61 m – 1,5 m had the ability to store approximately 9,58 l – 44,13 l of water, *Malus sp*. with a tree trunk perimeter of 0,7 m – 1,53 m had the ability to store approximately 10,99 l – 43,06 l of water. Other rates of specific bark water retention capacities were measured for *Carpinus betulus* - 0,702 g/cm^3, *Acer pseudoplatanus* - 0,578 g/cm^3, *Larix decidua* - 0,560 g/cm^3, *Betula pendula* - 0,521 g/cm^3 and *Pinus sylvestris* - 0,489 g/cm^3.(Fig.1.)

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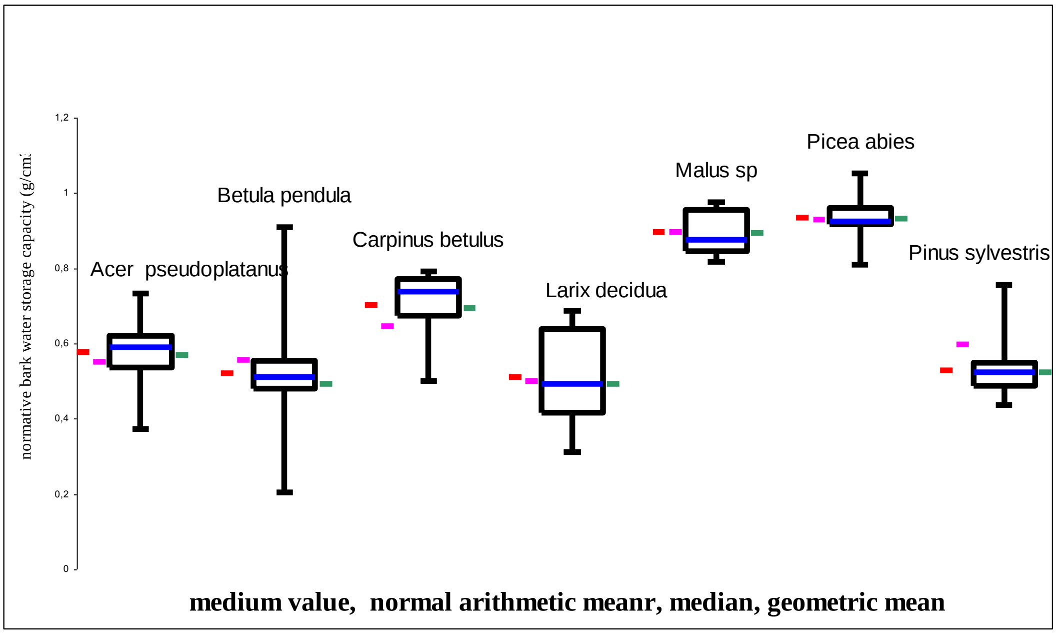

Fig.1 Specific bark water retention capacity.

The value of bark water retention capacity of the named trees after being converted to litres are as follows: *Carpinus betulus* with a tree trunk perimeter of 0,4m – 0,9m was storing 3,96 l- 12,17 l, *Acer pseudoplatanus* with a tree trunk perimeter of 0,8m – 2,3m was storing 9,73 l -38,41l, *Larix decidua* with a tree trunk perimeter of 0,7m – 1,95m was storing approximately 7,14 l – 27,73 l, *Betula pendula* and *Pinus sylvestris* with a ree trunk perimeters of 0,88m – 1,45m were storing 8,48 l – 19,23 l of water. Respectively while comparing the trees with the same tree trunk perimeter of 1 m, the highest value of bark water retention capacity was determined for *Malus sp*. - 0,886 g/cm^3 and for *Picea abies* - 0,858 g/cm$^{3.}$ On the other hand the lowest value of water retention capacity was determined for *Pinus sylvestris* - 0,502 g/cm^3 and *Betula pendula* - 0,342 g/cm^3 with the same tree trunk perimeter of 1 m. (Fig.2.)

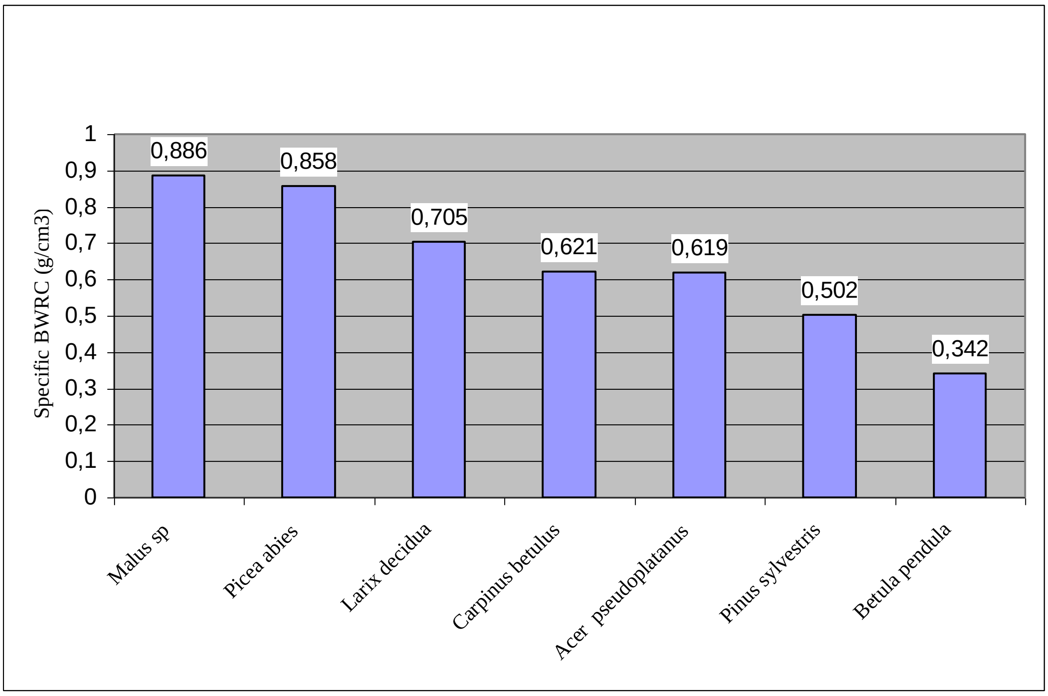

Fig. 2 Specific bark water retention capacity (BWRC) for particular trees with a tree trunk perimeter of 100 cm.

After the bark water retention capacity was determined the loss of moisture was measured. The average highest loss of moisture in 24 hours was reached by *Larix decidua* - 92%, *Carpinus betulus*, *Betula pendula* and

Malus sp. reached 91% of moisture loss in 24hours. The lowest percentage loss of moisture was reached by *Picea abies* - 88,7%, *Pinus sylvestris* - 85% and *Acer Pseudoplatanus* - 77,42%. (Fig.3.)

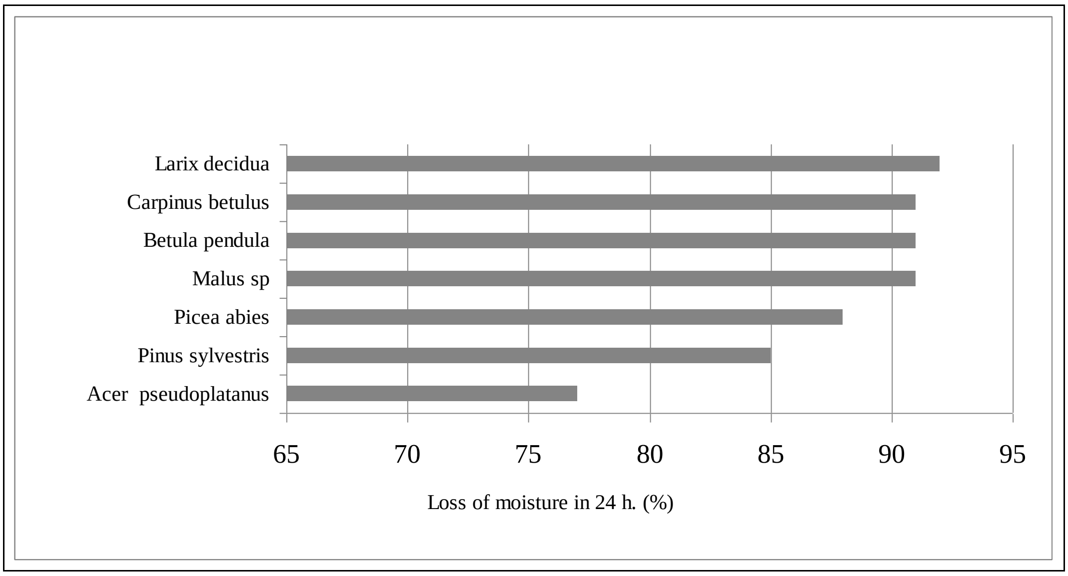

Fig.3 The loss of moisture in 24 hours (%) was averaged for different tree trunk perimeters of similar species.

Fig.4 shows the comparison of moisture loss in 24 hours for individual trees with a similar tree trunk perimeter of 1 m. The highest percentage of moisture loss for the trees with the tree trunk perimeter was reached by species *Larix decidua* and *Carpinus betulus* - 93%. On the other hand the lowest percentage loss of moisture for the trees with a similar tree trunk perimeter was reached by *Acer pseudoplatanus* - 82% and *Pinus sylvestris* - 84%.

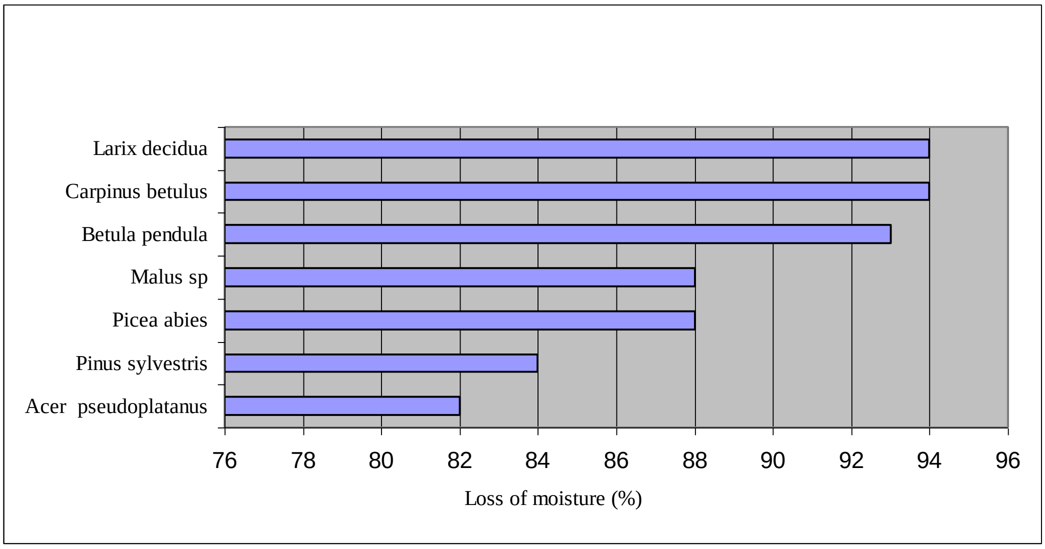

Fig.4. The loss of moisture in 24 hours (%) for particular tree species with a similar trunk perimeter of 100 cm.

There was an evident dependence on size of tree trunk perimeter and percentage of moisture loss for all named species of trees in 24 hours. The most evident is the species *Betula pendula.* With its trunk perimeter of 1,31m it reached the water loss of 85,74% in 24 hours. By contrast the species *Betula pendula* with its tree trunk perimeter of 0,15m had the percentage of moisture loss 98,66%. (Fig.5). This could be caused by the bark structure. *Betula pendula* with its tree trunk perimeter of 0,15m had a smooth bark with no fissures. In contrast *Betula pendula* with its tree trunk perimeter of 1,31m didn't have a smooth bark and we could see many fissures.

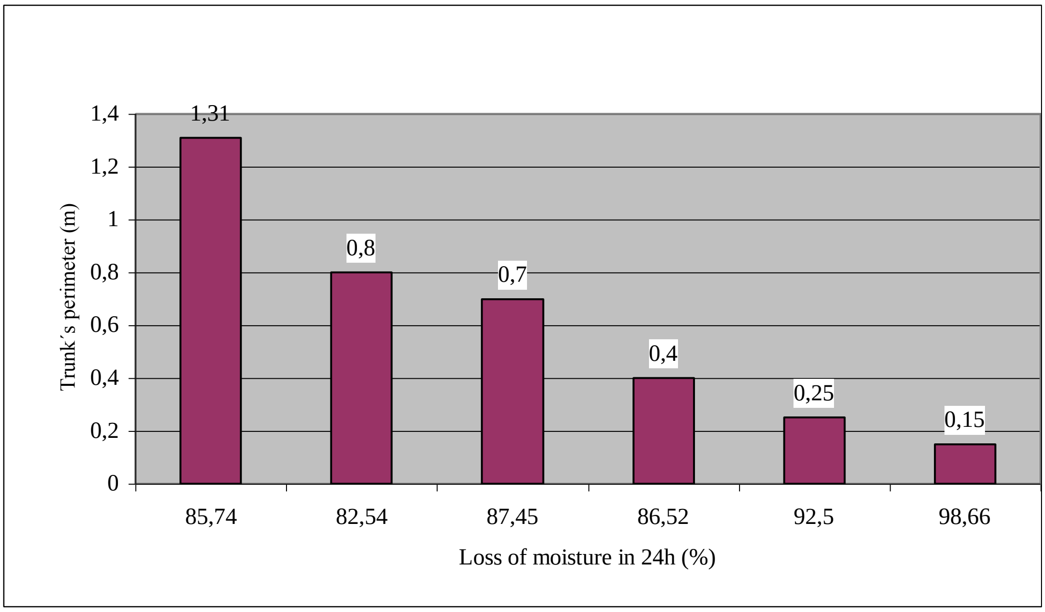

Fig.5. The loss of moisture in 24h. (%) for *Betula pendula*

4 DISCUSION

Information on bark water retention capacity is critical as it provides a measure of availability of a key resource for organisms living on tree boles (http://findarticles.com/p/articles/mi_qa3845/is_200601/ai_n17183717/pg_2?tag=artBody;col1). The observed differences in specific bark water retention capacity may be attributable to variation in bark roughness, bark morphology, and water behaviour on bark surfaces. The bark roughness has been documented affecting quantity of stemflow produced (Johnson, 1990). The rates of bark water retention capacity can be influenced by the age of the particular tree because as the tree grows the structure of its bark changes as well. We can say the older trees have a larger tree trunk perimeter and a higher occurrence of bark roughness. The deepness of fissure is getting higher. Due to these factors the bark can absorb more water and that's why the values of bark water retention capacity are higher for older trees. The morphology of bark, the number and size of fissures could be the significant parameters not only for the value of water retention capacity but for the maintenance of water in bark, too. The smaller the tree trunk perimeter and therefore the younger tree is the softer is the bark with a smaller number of fissures and therefore the water can flow down easily and more quickly and can't be captured by the bark. It is similar to the loss of moisture. The smaller the tree trunk perimeter and therefore the younger tree is the softer is the bark with a lower number of fissures and therefore the loss of moisture is higher compared to older trees. Although the older trees have a higher number of fissures and due to that the surface area for loss of moisture is higher the loss of moisture can be slowed down thanks to the water flowing down the deep fissures. The influence of trunk perimeter and therefore age of tree on the loss of moisture can be clearly seen on *Betula pendula.*(Fig. 5.)

It was important to compare the particular species of trees with a similar tree trunk perimeter for determination of interspecific variation of bark water retention capacity and subsequent loss of moisture. For comparison we chose trees with their tree trunk perimeter of 100cm.

There were interesting differences between bark water retention capacity and loss of moisture observed at the species *Malus sp*. and *Acer pseudoplatanus* as representatives of broadleaved trees. *Malus sp*. with its tree trunk perimeter of 100 cm had the highest rate of specific bark water retention capacity of all species and it was 0,886 g/cm^3 (Fig.2.), but moisture loss reached a middle rate out of all the trees and it was 88%. (Fig.4.) By contrast *Acer pseudoplatanus* with its tree trunk perimeter of 100 cm had the rate of bark water storage capacity 0,621 g/cm^3 (Fig.2.), but moisture loss in 24 hours was the lowest of all the observed trees and it was 82%. (Fig.4.) Similar differences between values of bark water retention capacity and loss of moisture were observed for species *Pinus sylvestris* and *Larix decidua* as representatives of conifers. The specific value of bark water retention capacity for *Pinus sylvestris* with its tree trunk perimeter of 100 cm is very small - 0,502 g/cm^3 (Fig.2.), but loss of moisture was small as well - 84%. (Fig.4.) It means that species *Pinus sylvestris* can keep back very little water but it is able to store it for a longer time. By contrast species *Larix decidua* with its tree trunk perimeter of 100 cm had the rate of normative bark water retention capacity 0,705 g/cm^3 (Fig.2.), but the loss of moisture during a 24-hour period was high as well - 94% (Fig.4). An opposite case occurred for *Picea abies* with its tree trunk perimeter of 100cm where the rate of specific bark water retention capacity was 0,858 g/cm^3 (Fig.2), but loss of moisture during a 24-hour period was small - 88% (Fig.4.), which states that it can retain a lot of water and it can store it for a long time. *Betula pendula* with its tree trunk perimeter of 100 cm had the rate of specific bark water retention capacity very small - 0,342 g/cm^3 (Fig.2.) and moisture loss was very high - 94% (Fig.4.). Consequently the species *Betula pendula* can´t retain a big amount of water and it looses it very quickly. The question is why some species of trees have the ability to retain a big amount of water in their barks but they can loose it very quickly, e.g.*Larix decidua* (Fig.2.,4.). Some species of trees can retain a small amount of water in their barks but they can store it for a longer time, e.g. *Acer pseudoplatanus* and *Pinus sylvestris* (Fig.2.,4.). And furthermore, some species of trees can retain a big amount of water in their barks and they can store it for a longer time, e.g. *Malus sp*. and *Picea abies* (Fig.2.,4.).

Franks and Bergstorm (2000 in http://findarticles.com/p/articles/mi_qa3845/is_200601/ai_n17183717/pg_2?tag=artBody;col1) state that bark water retention capacity and moisture availability may have an important implication for distribution and diversity of epiphytic lichen and bryophytes. Why do some species of epiphytic mosses from the genus *Orthotrichum* grow only on some particular trees and not on all of them? With a view of the measured value of bark water retention capacity and the ability to retain moisture for the longest period of time there would be theoretically the most suitable species of epiphytic mosses from the genus *Orthotrichum,* species of trees *Malus sp.* and *Picea abies*. Practically according to Vondracek (1993) *Picea abies* doesn´t occur as a host woody species for the genus *Orthotrichum*. By contrast the genus *Orthotrichum* can be often seen on the species *Malus sp.* According to Vondracek (1993) epiphytic mosses from the genus *Orthotrichum* don't occur on the next named conifer *Larix decidua* that has quite high rates of bark water retention capacity (Fig.2.), but it looses water quickly. By contrast epiphytic mosses from the genus *Orthotrichum* commonly grow on *Acer pseudoplatanus* (Vondracek 1993), that hasn't such high rates of bark water retention capacity, but is able to store water for a longer time (Fig.2.,4.). According to Vondracek (1993) epiphytic mosses from the genus *Orthotrichum* grow as well in smaller numbers on *Carpinus betulus* and *Betula pendula*, whose values of bark water retention capacity are low (Fig.2.) and percentage of moisture loss high. (Fig.4.). According to the occurrence of epiphytic mosses from the genus *Orthotrichum* on different host woody species (Vondracek, 1993), there was no clearly proved a dependence between bark water retention capacity and preference in choosing the host woody species rightly epiphytic mosses from the genus *Orthotrichum.* Therefore we can expect the occurrence of epiphytic mosses from the genus *Orthotrichum* can be influenced by other factors, e.g. chemical factors such as chemical composition of bark of a particular species of trees, concentration of individual nutrient elements, nitrogen compounds and acidity and physical factors such as light, temperature, atmospheric humidity, morphological adaptations of epiphytes or air quality in surroundings of trees, toxic gases and influence of towns and industries (Barkman, 1958).

5 CONCLUSIONS

The value of bark water retention capacity change not only in dependence on trunk perimeter and therefore age of tree of particular species, but it is different for individual species of trees with a similar size of tree trunk perimeter. Loss of moisture in 24 hours period is different for individual species. A key role for different values of bark water retention capacity for individual species of trees can have the morphology of bark, both macrostructure and microstructure.

With a view to the measured value of bark water retention capacity and ability to retain moisture for the longest period of time there would be theoretically the most suitable species of epiphytic mosses from the genus *Orthotrichum,* species of trees *Malus sp.* and *Picea abies*. Practically according to Vondracek (1993) *Picea abies* doesn´t occur as a host woody species for the genus *Orthotrichum*. By contrast the genus *Orthotrichum* can be often seen on the species *Malus sp.*

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RESUMÉ

Řada studií ukazuje, že normativní vodní kapacita bývá značně rozdílná mezi spolu vyskytujícími se druhy stromů. Stromy zachytí mnohem více vody přes povrch kůry než povrch listů.. Na množství podkorunových srážek a také množství zachycené vody kůrou, může mít vliv celkový povrch kůry (počet a hloubka zářezů), tloušťka kůry, tvar koruny, velikost a věk stromu, roční období, meteorologické podmínky. Množství vody, kterou strom zachytí pomocí kůry a schopnost daného druhu stromu si držet vodu v kůře po co nejdelší dobu, může mít také významný vliv na organismy žijící na kmeni stromu a v kůře. Proto poznání rozdílu mezidruhové vodní kapacity nám může pomoci v lepším pochopení závislosti výskytu některých organismů žijících na kmeni stromu.

Pro tuto studii bylo vybráno sedm druhů stromů vyskytující se ve třech rozdílných lokalitách (Osoblažsko, Odersko, Vsetínsko). Byly vybrány tyto druhy stromů: *Acer pseudoplatanus, Betula pendula,Carpinus betulus, Malus sp*. jako zástupci listnatých stromů, *Larix decidua, Picea abies, Pinus sylvestris,* jako zástupci jehličnatých stromů.

Laboratorní výsledky ukázaly, že z uvedených stromů měly nejvyšší hodnotu specifickou vodní kapacity *Picea abies* a *Malus sp.* Průměrná hodnota vodní kapacity ze všech tří lokalit činila pro *Picea abies* 0,934 g/cm^3 a pro *Malus sp*. byla naměřena vodní kapacita 0,914 g/cm^3. Při srovnání stromů stejného obvodu 1m byla naměřena nejvyšší hodnota vodní kapacity pro druh *Malus sp.* 0,886 g/cm^3 a pro *Picea abies* 0,858 g/cm^3 naproti tomu nejmenší hodnoty vodní kapacity pro stromy s obvodem kmene 1m měly druhy *Pinus sylvestris* 0,502 g/cm^3 a *Betula pendula* 0,342 g/cm^3. Průměrnou nejvyšší ztrátu vlhkosti za 24 hod dosáhl druh *Larix decidua* 92%. *Carpinus betulus, Betula pendula* a *Malus sp*. dosáhly 91% ztráty vlhkosti za 24hodin. Nejmenší procento ztráty vlhkosti měly druhy *Picea abies* 88,7 %, *Pinus sylvestris* 85% a *Acer Pseudoplatanus* 77,42%. U všech druhů stromů byla zřejmá závislost ve velikosti obvodu stromu a procentuální ztrátou vlhkosti za 24 hodin. Nejzřetelnějšíi to bylo u druhu *Betula pendula.* Při obvodu kmene 1,31m dosahovala ztráta vlhkosti za 24 hodin 85,74%. Naproti tomu *Betula pendula* s obvodem kmene 0,15m byla procentuální ztráta vlhkosti 98,66%.

Řada studií také ukazuje že vodní kapacita a vlhkost kůry má značný vliv na rozšiřování a druhovou diverzitu epifytických lišejníků a epifytických mechorostů. Proč ale některé druhy epifytických mechorostů rodu *Orthotrichum* rostou pouze na některých druzích stromů a na některých druzích stromu nerostou? Z hlediska naměřených hodnot vodní kapacity a také schopnosti uchovat vlhkost po co nejdelší dobu by teoreticky měly být nejvhodnější pro epifytické mechorosty rodu *Orthotrichum* stromy druhu *Malus sp.* a *Picea abies*. Prakticky se však *Picea abies* jako hostitelská dřevina pro rod *Orthotrichum* vůbec nevyskytuje. Naproti tomu lze rod *Orthotrichum* nalézt ve velké míře na *Malus sp.* Také na dalším jehličnanu *Larix decidua*, který má vcelku vysoké hodnoty vodní kapacity, ale rychle vodu ztrácí, se epifytické mechorosty rodu *Orthotrichum* nevyskytují. Naproti tomu běžně roste na *Acer pseudoplatanus*, který nemá tak vysoké hodnoty vodní kapacity, ale je schopen si uchovat vodu po dlouhou dobu. Dle revize rozšíření druhů rodu *Orthotrichum* provedenou Vondráčkem (1993), rostou také v menší míře na stromech *Carpinus betulus* a *Betula pendula*. Hodnoty jejich vodní kapacity jsou nízké a procentuální ztráta vlhkosti je veliká. Proto můžeme předpokládat, že výskyt epifytických mechorostů druhu *Orthotrichum* může být ovlivněn jinými faktory, například chemismem kůry jednotlivých druhů stromů a nebo také kvalitou ovzduší v okolí stromu.